APPLICATION FOR PATENT

METHOD AND APPARATUS FOR DISTRIBUTING MATERIAL IN A PROFILE EXTRUSION DIE

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Background of the Invention

In the field of extruding complex shapes one of the more challenging items to produce is the flexible gaskets used for sealing refrigerators, automobile doors, hatches, and the like. These products utilize a complex cross section which requires considerable dexterity for the die to accurately reproduce the product. In order to accurately extrude these shapes, the die must completely fill while maintaining a continuous flow of plastic. The dies used in this type of process are generally referred to as profile dies. In manufacturing such dies it is often necessary to construct the die, use the die to see how it works and then, through a series of corrections, gradually bring the die into tolerance. This trial and error method is time consuming and expensive.

Profile dies are also used for extruding large plastic parts, for example fence posts and rails. In this instance, it is not a problem of intricate areas to fill, it is more a problem of providing a large volume of flow which is uniformly distributed over a large die outlet.

It is a purpose of this invention to construct a profile die which provides a balanced flow to the extremities of the die passage and to provide a more accurate and simpler way to construct a profile die within closer tolerances. A die with close tolerances will allow the product to be extruded with less material with a resulting savings in cost.

Another purpose of this invention is to distribute a large volume of molten plastic uniformly across a large die outlet while maintaining a reasonable flow rate so as to avoid dead spots which may result in scorching or buildup of plastic within the die.

Summary of the invention

A profile die system is constructed for extruding a flexible product having a complex cross section. The die system of this invention consists of an assembly of axially aligned generally cylindrical modules. A series of passages are provided to deliver molten plastic from the input to the die in a balanced flow. To accomplish this a distribution module is constructed with an inlet to receive plastic from an extruder. The distribution module has a plurality of distribution channels extending downstream in the die system. The distribution channels are sized and positioned to supply selected regions of the extrusion passage. The distribution channels exit at the downstream face of the distribution module. A transition module is positioned downstream of the distribution module and is constructed with a series of transition passages extending from its upstream to its downstream face. In the assembled position, the inlets of the transition passages are aligned with the exits of the distribution channels to receive molten plastic therefrom. The cross section of the transition passages gradually converts a generally cylindrical flow to a cross sectional shape representative of the region of the die selected for the particular passage.

In another embodiment, the distribution modules take a primary role and provide a series of stepped volume

expansions in which each module increases the number of channels in a predetermined manner. The volume of the required die output is calculated and divided into a series of volume steps. This is accomplished by separating the overall die area into smaller regions for receiving flowing plastic from an outlet of a distribution passage. The number of appropriate regions depends on the flow rates, pressures, and other parameters required to completely extrude the product to tolerance.

It will be necessary where large products are being extruded to have several steps in which the number of supply channels are multiplied to achieve the supply to each of the selected regions. Each step would involve a module that would multiply the number of supply channels. Depending on the complexity of the product shape it may be possible to feed the die extrusion channel directly from the downstream distribution module without the need for interim shape transition modules as indicated above.

In constructing the distribution channels, it is first necessary to analyze the shape of the extrusion passage and divide its cross sectional area into regions for concentration of plastic according to the nuances of its shape. The number of distribution channels is determined by the number of regions selected. The cross sectional area of each of the distribution channels is designed to be less than the cross section of the profile die system inlet and consistent with the flow area of the region serviced by the channel. In this manner the overall flow volume from the extruder is metered proportionally into the selected regions. Each of the transition passages are constructed to have a reduced

cross sectional area from that of the distribution channel with which it communicates. Therefore, the flow volumes in each of the regional flow streams is gradually reduced from the inlet of the distribution module to the extrusion die, thereby creating an overall funnel effect in each of the regional streams. In the transition module the passage is constructed to convert the generally cylindrical flow to a shaped flow more compatible with the entrance to the die passage in each of the selected regions.

The selection of flow regions in the case of large area die outputs having simple shapes depends more on the size and flow characteristics of the material. The flow area of the die output is divided into sufficient regions to insure a uniform distribution of plastic throughout the die under a consistent pressure and flow rate.

In either embodiment it is important that the area of the die profile be divided into flow regions and that the distribution channels are configured to supply a balanced and uniform flow to each of the flow regions.

Description of the Drawing

The preferred embodiment of the invention is described in more detail below with reference to the drawing in which:

Figure 1a is a cross sectional view of the profile die system of this invention;

Figure 1b is an end view of the upstream face of the transition module of this invention;

Figure 1c is an end view of the downstream face of the transition module of this invention;

Figure 1d is an end view of the upstream face of the die module of this invention;

Figure 2 is a schematic view of a distribution system for large die outputs;

Figure 3a is a side sectional view of an extrusion die having a two step volume expansion;

Figure 3b is an upstream view of the interface surface of module 31;

Figure 3c is an upstream view of the interface surface of module 32;

Figure 3d is an upstream sectional view of the interface surface of module 33, taken along section line A-A; and

Figure 3e is a top sectional view of the extrusion die of figure 3a.

Detailed Description of the Invention

As shown in figure 1a, a profile extrusion die system 1 is constructed having a distribution module 2, a transition module 3 and a die module 4. A die plate 5 retains the modules in the assembled condition and

provides a straight exit 21 for the flowing plastic from the die module 4. Inlet flange 6 is shown integral with the distribution module 2 and encloses inlet 11 to the profile die system 1. The inlet flange 6 is constructed to connect to the extruder which supplies the plasticized material to the profile die system 1 for extrusion into a complex shape as illustrated in figure 1d.

A series of distribution channels 7, 8, 9, and 10 (not shown) are constructed by electric discharge machining or other means within the distribution module 2. The number and size of the distribution channels are selected relative to the complexity of the die. The cross sectional area of each of the distribution channels 7-10 is less than the cross sectional area of the inlet. In the example shown, four distribution channels are selected to meter the flowing plastic into four regional flow streams having volumes relative to regional portions of the extrusion passage 19. Each of the distribution channels exit at the downstream face 20 of the distribution module 2.

A transition module 3 is assembled adjacent to the downstream face 20 of the distribution module 2. Transition passages 11 through 14, as shown in figure 1b, are constructed by electric discharge machining or other means. The passages 11 - 14 extend from entrances in upstream face 15 (figure 1b) of the transition module 3 to exits in the downstream face 16 (figure 1c) in module 3. In the assembled position, the entrances of the transition passages 11 - 14 align with the exits of the distribution channels 7-10 respectively to receive flowing material.

Consistent with the overall flow strategy of the profile die system of this invention, the flow area of each of the transition passages is reduced relative to the flow area of each of the distribution channels to which it is connected. In addition the cross section of the transition passage changes over its length to convert the flow from generally cylindrical to a shaped flow consistent with the shape of the selected region of the die cross section. The exits of the passages 11-14 are shown in figure 1c.

To accomplish the balanced flow, the shape of the cross sectional shape of die passage 19 is analyzed and accordingly divided into a plurality of regions, for example; A, B, C, and D shown in figure 1d. Each region is selected to coincide with areas of possible distribution difficulties where complete filling of the die is critical. The filling of the die throughout its volume must be accomplished with constant velocity and flow. After the regions are selected, the percentage of flow volume for each region is calculated and related back to the size of the distribution channel which supplies the particular region.

For illustration purposes, the cross section of extrusion passage 19, may be divided into regions A, B, C, D as shown by dotted lines in figure 1d. In order to determine the proportional flow area of the channels 7-10, the ratio of the area of the region supplied by a channel, i.e. channel 7 supplies A, channel 8 supplies C, etc., to the overall area of the die profile is determined. The channel is sized to accommodate a flow stream consistent with the requirements of the related region.

To insure an overall uniform flow at a consistent velocity, the regional flow paths constructed by the assembly of distribution channels 7-10, transition passages 11-14, and extrusion passage 19 are designed for a funnel effect. This is accomplished by reducing the cross sectional areas of adjoining portions of the flow path from the upstream to the downstream ends of the regional flow paths. This assists in maintaining a constant velocity of the flow. The gradual increase in pressure which arises within the funnel shaped flow paths forces the molten material into the most remote section of the die.

The embodiment shown is for illustration purposes only, as the possible die shapes are infinitely variable. In each instance, depending on the cross section of the product, a specific flow path must be designed. In very complex dies it may be necessary to use multiple transition modules. Where necessary, bushings may be used to throttle the flow from the distribution module to the transition module as a means of adjusting flow to balance or correct for manufacturing inaccuracies.

In addition for special applications involving the extrusion of multiple materials, it may be necessary to provide separate inlets and distribution channels to individual regions. A particular region would be supplied separately and maintained as an independent channel from the inlet to its outlet in order to extrude a product having components of different materials. This could be accomplished in a common or independent distribution module. In some instances a transition

module for one component could be used as the distribution module for another component. The extruded components would be joined and welded together in the final product. In this manner extruded assemblies having two or more components of different materials can be processed in the same profile die assembly.

Another embodiment of this invention is shown in figures 2-3e. In this instance the extruded product is of relatively simple cross section, but requires a large volume of flow, for example in the case of extruding plastic/wood composite fence posts. The posts can be designed as solid or hollow, as is shown in figure 3a.

The distribution system of this embodiment comprises a series of capillaries 27 arranged in a sequence of distribution modules 22-26. As shown in figure 2, the output area at die outlet 28 is divided into 32 regions for individual supply of plastic through capillaries 27. The flow area is doubled at each module to expand the area of the inlet 21 to accommodate the die output area at 28. This capillary network serves to act as a reservoir to restrain the plastic under pressure and control the flow of plastic at a speed that will provide a uniform flow at the output 28. Depending on the size of the die output area and the number of regions, it may be desirable to provide a gradual reduction in passage diameter at each module, namely to use the funnel effect, as described above. The configuration of capillaries may take on an infinite number of combinations depending on the size of the die output and the flow characteristics of the material being extruded. The passages of each module have inlets and outlets which are aligned in the assembled state with the adjacent

upstream and downstream modules to receive and supply flowing plastic from the upstream inlet 21 to the downstream outlet 28.

Figures 3a -3e show a system in which the output flow area is divided into six flow regions E - J. Each region is supplied by supply passages as shown, for example: Region E is supplied by passage 41 and so on. The die system 29 consists of an inlet flange 30 having a supply passage 45. This passage receives molten plastic directly from an extruder (not shown). Distribution module 31 contains a pair of capillaries or passages 46 which are split, as shown in figure 3e into side by side passages 46, 48, and 47, 49. This results in multiplying the flow area approximately by a factor of 4. The outlets of these passages are shown in the upstream view of face 37 of module 31 and are aligned with the passages of adjacent downstream module 32. A second expansion step is provided by module 32 which expands the four passages of module 31 to eight passages at the outlet of module 32. The upstream face 38 of module 32 will have eight outlets. A transition module 33 is provided to direct the divided outputs to the selected regions E-J. The relative arrangement of, the paired outlets 41,50, 42,51, 43,52, and 44,53 relative to the selected flow regions E-J is shown in the end view of figure 3d. It can be seen that, all flow regions of the large area die outlet 39 of extrusion passage 40 are supplied by at least one distribution passage. Die 34 is assembled with the distributions modules 31 and 32, the transition module 33, and die 34 and is held in place by a suitable clamp 35.

In general with large dies, which extrude products having simple cross sectional profiles, the transition module 33 plays a minor role. The important part of the construction of this embodiment involves the dividing of the output into an appropriate number of regions to insure a uniform flow throughout the die 34. In either case it is an essential step to divide the area of the die outlet profile into individual flow regions and to provide a distribution system which will provide a balanced and uniform supply of flowing plastic to each of the flow regions.